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HYDRAULICS DIVISION

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HYDRAULICS DIVISION

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FOR FISCAL YEAR 1985/86

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HYDRAULICS DIVISION
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PREFACE

Work in 1985/86 continued to meet the needs of clients in the Department of the Environment and also in other agencies and in the private sector.

Significant progress is being made with ice research, river models and air interaction research. Noteworthy contributions were made to the St. Clair River pollution investigation in both river mechanics and urban runoff.

Dr. Krishnappan is to be congratulated in winning for the second time, the Keefer Medal awarded by the Canadian Society for Civil Engineers for the best paper in their journal. Dr. Krishnappan's winning paper compared the performance of the MOBED model with the HEC-6 model.

At the end of the year, an interesting and informative Symposium on Cohesive Shores was organized by Mr. A. Zeman. The proceedings were edited by Dr. Skafel and will be available in the next fiscal year.

Engineering and technical staff did excellent work with the design and installation of data-gathering equipment for the Lake St. Clair investigation.

Overall, it has been a busy and productive year. The Hydraulics Division staff should be well pleased with the results.

T. Milne Dick
Chief
Hydraulics Division

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DIVISIONAL OBJECTIVES

The Hydraulics Division undertakes research in the hydraulics of inland waters and also provides services to the Inland Waters Directorate and the National Water Research Institute.

For research the objective is:

To advance, apply and communicate scientific and engineering knowledge and understanding of all aspects of the physical actions and interactions with air and sediments of inland waters for the use of planners, engineers and managers of such resources throughout Canada.

Technical service to others has two objectives:

To develop, undertake and promote efficient and standardized methods for measurement and sample collection including calibration for the use of scientists, engineers and technologists working in the laboratories and in the field.

To provide efficient illustrative photographic and drafting services for the use of scientific and technical staff for use in their presentations and publications.

ENVIRONMENTAL HYDRAULICS SECTION
HIGHLIGHTS

Many of the 85/86 studies in the river engineering area were carried out at the request of operational groups of the Inland Waters Directorate. These included studying the effectiveness of a channel conveyance improvement scheme for the Qu'Appelle River in Saskatchewan; the change in flow resistance in the Pitt River, British Columbia, between the flood and ebb flow periods; the possible impacts of a proposed coal mine development in the Flathead River Basin in British Columbia; and discharge measurement alternatives for the Milk River at the Alberta-Montana border. Investigations for the Qu'Appelle proposal indicated that the scheme will lose its effect in about seven years and flooding will reoccur so that alternate schemes should be investigated. Other studies included scale effects and flow resistance in sediment transport problems and the extension of the model MOBED to include sediment sorting. Dr. Krishnappan's paper comparing the MOBED model with the model HEC-6 was awarded the Keefer medal for the best paper in the Canadian Journal of Civil Engineering in 1985.

Investigations into toxic contaminants in urban runoff in the Upper Great Lakes Connecting Channels were initiated with the establishment of field sites in Windsor and Sarnia. The field data will be used to produce monthly loadings of toxic substances in runoff discharges.

In response to the discovery of toxic puddles in the bottom of the St. Clair River, additional surveys were made which showed that municipal source loadings of these substances were only minor. Experiments were also conducted in the laboratory to investigate the behaviour of perchloroethylene in flowing water and to measure its rate of dissolution. These findings have proven to be useful for those who are dealing with Dow Chemical regarding the cleanup operation.

Ice jam observations continued on the Thames River and the thickness of an ice jam has been measured in detail, the first time this has been done. This is valuable information for the testing of theories and models. Theoretical work on ice jams was also advanced by improving a

mathematical model so that ice jams in non-rectangular channels can be handled. Laboratory experiments on ice jam phenomena were delayed due to educational leave for J. Wong.

Technology transfer work was also carried out by the staff. This included chairing of the Canadian Society of Civil Engineering Task Group on River Models and the National Research Council Working Group on Ice Jams. Monographs are being prepared by these groups. A NATO workshop on urban runoff pollution was directed by J. Marsalek who also wrote several chapters for two UNESCO manuals on urban drainage design.

REPORTS ON INDIVIDUAL STUDIES

Prediction of Sediment Sorting Using MOBED: Users Manual Update II

The model MOBED was updated to include a sediment sorting algorithm. With this algorithm, the model is now capable of predicting the size distribution of the bed sediment as a function of time and distance along the river in addition to predicting the usual water and bed level changes and other hydraulic and sediment transport characteristics. The details of the algorithm and the changes that resulted to the source code and input data arrangements as a result of the inclusion of the algorithm are described in a users manual update. (Krishnappan)

Application of MOBED to the Qu'Appelle River Between Craven and Pasqua Lake

The model MOBED was applied to the Qu'Appelle River between Craven and Pasqua Lake to test the effectiveness of the channel conveyance improvement scheme proposed by the Saskatchwan Water Corporation. The proposal involves several meander loop cutoffs and dredging of the existing channel at several reaches at an estimated cost of 4.5 million dollars. The model predictions (see Fig. 1) indicate significant bed level changes with degradation in the upstream reaches and aggradation in the downstream reaches near the lake. (Krishnappan)

Scale Effects in Physical Models of Sediment Transport in Uni-Directional Flow

Experiments in the 2 m flume were carried out to establish the scale effects in physical models dealing with sediment transport in river flows. A paper describing the experimental procedure and results has been submitted to the IAHR Symposium on Scale Effects in Modelling Sediment Transport to be held in Toronto in 1986. (Krishnappan, Engel)

Reverse Flow Over Dune Profiles

Mathematical modelling of the stage and discharge of the lower Fraser River in British Columbia, is being carried out by the Water Resources Branch. It was found that for the Pitt River, a tributary of the Fraser, different values of the Manning's roughness coefficient had to be used for the flood flow and ebb flow periods. This change in bottom roughness may be caused by the interaction of the reversing flow and the sand wave profiles. Experiments were carried out in the 1 m flume using artificial dunes to investigate this phenomena. A report is being completed. (Lau)

St. Clair River Study

In response to the problem of the tarry puddles discovered in the bottom of the St. Clair River, tests were conducted in the laboratory to investigate the physical behaviour of perchloroethylene in flowing water. A mechanism in which the puddles could be covered and uncovered by moving sand waves was discovered. The rate at which this material can be dissolved by the flow was also measured. Modelling of some contaminant distributions measured at Port Lambton by the Water Quality Branch was carried out.

Because contaminant transport by sediments may be significant, a plan has been set up to measure the bed load and suspended load at a number of transects in the St. Clair River. (Lau)

Water Quality and Quantity Committee: Flathead River International Study Board

Under the directives of the International Joint Commission (IJC), the Flathead River International Study Board is assessing the possible impacts of the proposed coal mine development near Cabin and Howell Creeks in British Columbia. The study board has established a number of technical committees for this purpose. Dr. B.G. Krishnappan has been chosen as a member of the Water Quality and Quantity Committee. He has contributed to the baseline data report as well as to the prediction of sediment transport in the Flathead River System. (Krishnappan)

CSCE Task Group on River Models

At the request of the Research Committee of the Hydrotechnical Division of the Canadian Society of Civil Engineers, a task group was initiated, chaired by B.G. Krishnappan, to evaluate the existing (public domain) river flow models. A total of ten models dealing with both steady and unsteady flows in rigid and mobile boundary channels were selected and will be evaluated by applying them to identical data sets. The computer codes of these models are now available in the computer system at the Canada Centre for Inland Waters. (Krishnappan)

Migration Speed of Dunes

Different methods of computing dune speed from bed profile records as well as the geometric characteristics of dunes are being investigated using experiments in the 2 m flume. The migration speeds of dunes are useful for the computation of bed load discharge in large rivers whereas bed form heights and lengths provide information to better understand flow resistance and changes in bed elevation of navigation channels. A typical dune bed in a large sediment flume is shown in Fig. 2. (Engel)

Hydraulic Efficiency of Bed Load Samplers

Studying the hydraulic efficiency enables more correct estimates of local sediment transport. Tests in the 1 m flume were conducted to obtain the efficiency of the basket sampler. (Engel)

Development of Current Meter Rotors

A plastic rotor design has been successfully modified to improve performance. Preliminary tests have indicated that a reduction in threshold speed from 4 cm/s to 2 cm/s can be achieved which is important for low flow measurements. Additional tests to examine the angular response of the proposed rotor are being conducted. The final results will be used by Water Survey of Canada to develop a casting mould for mass production of the rotor. (Engel)

Evaluation of Water Level Recording Systems

The performance characteristics of float type and gas-purge type sensors, pressure transducers and satellite platforms are being systematically evaluated in the laboratory. The results will go to Water Survey of Canada to provide baseline information for the updating of water level recording instrumentation. (Engel)

Flow Measurement Alternatives

There is a need to explore alternatives to present methods of flow measurements for application to mobile bed rivers. One possible choice is the electromagnetic total flow meter. Tests were conducted to examine the behaviour of this type of meter when sediment is deposited in the measuring cross-section. Tests showed that the original calibration was not significantly affected by changes in the cross-section. (Engel)

Stage-Discharge Curves for Compound Weir

Using theoretical considerations and a hydraulic model, rating curves were developed for free flowing and submerged flow conditions. Theoretical equations showed good agreement with model data. The work was requested by Atomic Energy of Canada Ltd. (Engel)

Modelling Runoff Transport in Drainage Networks

The operation of channel junctions and their role in runoff transport in drainage networks are poorly understood. To alleviate this situation, a joint study of channel junctions was conducted by the Institute and the American Public Works Association. The study dealt with head losses at three types of junctions: manholes with a 90° bend, junctions of a main with a lateral, and junctions of two opposed laterals. Head losses at typical layouts of these structures were evaluated and new designs reducing typical losses by more than one half were developed. The study has been completed and the final report is now available. The study results were supplemented by literature data and used to prepare a section on junction hydraulics for an engineering handbook under preparation. (Marsalek)

NATO Workshop on Urban Runoff Pollution

This workshop funded by NATO, was held in Montpellier, France, from August 26 to 30, 1985, with J. Marsalek serving as the program director. The workshop provided a discussion forum for about 40 invited leading experts from 14 countries. Workshop activities produced state-of-the-art reviews on, and future research directions for, such discussion subjects as sources of pollution in urban runoff, toxic substances in urban runoff, modelling of runoff quality and impacts on receiving waters, and runoff quality control and mangement. The final workshop proceedings will be published in 1986. (Marsalek)

Pollutants in Urban Runoff

Further studies of pollutant sources and their transport were undertaken in two Burlington test catchments. These studies addressed the problems connected with both the conventional and toxic pollutants.

An evaluation of the rainwater contribution to urban runoff quality was carried out using data from the Blair Road site. It showed that a significant portion of certain pollutants was derived from rainwater and not from the land. Some field data showing the rainwater and runoff pollutant loadings are shown in Fig. 3. (Marsalek)

Support of UNESCO Activities Under the International Hydrological Program (IHP)

In support of the UNESCO activities under the IHP, final drafts of four chapters for two UNESCO manuals on urban drainage design and acquisition of supporting data have been prepared and submitted to UNESCO. These chapters dealt with urban drainage design parameters, drainage hydraulics, collection of urban hydrological data, and organization of data collection programs. When published in 1986, the UNESCO manuals will provide authoritative and comprehensive guidance for urban drainage design, with a special reference on the conditons in less developed countries. (Marsalek)

Toxic Contaminants in Urban Runoff Draining into the Upper Great Lakes Connecting Channels (UGLCC)

Evaluation of loadings of toxic contaminants in urban runoff draining into the Upper Great Lakes Connecting Channels has been initiated. Towards this end, field sites for the monitoring of toxics in runoff have been established in Windsor and Sarnia, and additional sites will be selected in Sault Ste. Marie. Runoff samples have been collected in storm sewers as well as at combined sewer outfalls.

Collected samples are analyzed for four groups of persistent toxic substances: PCB's, organochlorine pesticides, PAS's and toxic inorganics. Field data will be used in conjunction with computer simulations to produce monthly loadings of toxic substances in runoff discharges. Such loadings will then form one of the inputs to the inventories of toxics in the Upper Great Lakes Connecting Channels.

Additional work has been done in support of the Departmental study of the St. Clair River pollution in Sarnia. Following a field survey, annual loadings of selected trace organics from municipal sources were estimated and used in comparative evaluation of various sources. The municipal source loadings of the substances found in tarry puddles in the St. Clair River were only minor. (Marsalek)

Waterford River Basin

Effects of urbanization on water resources in the Waterford River Basin (Newfoundland) have been studied for several years in cooperation with several federal and provincial agencies. Following the completion of field data collection, the modelling of streamflow for the entire basin has been initiated using the Hydrologic Simulation Program - Fortran (HSPF). The model has been set up for the basin and calibrations have started. Model simulations will be used to investigate the effects of various basin development scenarios on flows in the Waterford River. (Marsalek)

Field Studies of River Ice Jams and Floods

This is a long-term field observation program, initiated in 1979. Emphasis is on collection of quantitative data needed to address deterministic and statistical aspects of ice breakup and jamming. Observations are carried out in the Thames and Grand Rivers. This year, January thaw caused a jam in the Thames River near Chatham which later froze in place, thus permitting safe access and measurement of the jam's configuration (Fig. 4). This is the first time that ice jam thickness

has been measured in detail and the data will enable comprehensive testing of pertinent theoretical concepts. (Beltaos)

Laboratory Studies of Ice Jams

To study the interaction between jams and intact ice covers, a process that governs jam formation, stability and release, it is necessary to simulate the cover using a material of suitably scaled down strength properties. Work to develop such a material continued this year and flexural strengths as low as 15 kPa were achieved. Preliminary flume tests indicated satisfactory performance. (Beltaos)

Theoretical Studies of Ice Jams

An important aspect of ice jams is their configuration near the toe (downstream end) because it influences jam stability and thence peak water level. A mathematical model was developed earlier to predict the characteristics of the downstream transition of equilibrium jams in rectangular channels. This year, the model was modified to handle prismatic channels of non-rectangular cross-section (Fig. 5), as a further step toward complete simulation of natural stream geometry. (Beltaos)

Advice to Inland Waters Directorate, Atlantic Region

Advice was provided on ice-related aspects of the Canada-Newfoundland Flood Damage Reduction Program hydrotechnical study on the Rushoon River at Rushoon. (Beltaos)

Working Group on River Ice Jams

The National Research Council of Canada has formed a Working Group on Ice Jams, chaired by Dr. S. Beltaos. The Group's initial tasks have been completed and work is now in progress to produce a monograph on ice jams.

Frazil Ice

Much of 1985 was spent in treating the field data obtained from the Lachine Rapids, mainly in correcting the data and putting them into computer banks. The field measurement showed that the river water can be in a supercooled state for an extended period of time. Anchor ice can build up to as thick as two metres. Frazil measurement showed that frazil comes in waves and the concentration at one point can fluctuate over a wide range. However, the mean frazil distribution curve with depth is well defined. Fig. 6 shows the distribution of frazil with depth for one of the measurements. From Fig. 6 we see that most of the frazil was in the first 0.5 m of the flow. The frazil instrument developed earlier was used in measuring frazil and was found to perform satisfactorily. The highest concentration measured before frazil slushes reached the pancake ice state was less than 20 percent. (Tsang)

SHORE PROCESSES SECTION
HIGHLIGHTS

The work in the Section this year has covered an interesting and useful mix of activities ranging from problems posed by clients to studies on basic processes. Work on special requests included preparation of a handbook contribution on wave forecasting, sediment surveys in the St. Lawrence River in support of the Inland Waters Directorate (IWD), Quebec Region, sediment surveys in the St. Clair River in support of the study on tarry puddles, organizing a symposium on cohesive shores, and participating in Open House. Basic studies were conducted on the initiation of surface waves by wind, turbulent mixing beneath whitecaps, and subaqueous erosion of till.

The budget of sediments on the shore and in the nearshore zone for the central reach of the north shore of Lake Erie was prepared. Of the material lost from the bluffs, the sands tend to end up on Long Point, while the clays and silts are lost to the deep basins. The subaqueous erosion of tills is of direct importance to shore erosion. Early findings indicate that the wave induced bottom shear stresses and the erodibility of the till are the dominant variables controlling the erosion.

The disposition and character of the sediments in the nearshore zones on the Great Lakes continues to be of interest to many clients. Several requests for information were processed. In addition, work was started on compiling information for Lake St. Clair, and some work was done on the St. Clair River. In support of the IWD, Quebec Region, a sediment survey was conducted in Lac St-Louis. A list of waste sites in the shore zone of the lower Great Lakes has been prepared. The locations have been examined to determine their potential hazard in terms of releasing contaminants to the adjacent lakes as a result of shore recession.

Initial field studies were conducted to gain a better understanding of turbulent mixing under whitecaps. Analysis of the data will focus on establishing velocity statistics important to the design of structures,

mixing parameters important to spread of pollutants, and the loss of energy from the wave field. Measurements of wave dissipation in the shallow water of Lake St. Clair are being used to advance models on wave forecasting in shallow water.

Many harbours need modifications to reduce the wave agitation inside. A technique suitable for some is to line the entrance channel with rubble. Studies were undertaken to establish design information as to the extent of lining required to meet agitation criteria. Pipelines on the sea bed are subject to various forces. Work was begun to examine the wave forces on submerged pipelines with particular reference to situations typical in the Beaufort Sea. Pressure transducers have been widely used to measure waves. The problems encountered using this technique have been examined in a report.

REPORT ON INDIVIDUAL STUDIES

Waste Disposal Sites in the Coastal Zone

An evaluation of the potential hazard of these sites in the Lower Great Lakes has been carried out from the point of view of proximity to the shoreline, local recession rate, subsurface hydrogeology, and (to a lesser extent) the nature of the wastes dumped at the sites. Data for the study were supplied by the Ontario Ministry of the Environment (Waste Management Branch). Preparation of the data for publication is still incomplete, but the results point clearly to Lake Ontario as the lake where such waste disposal sites pose the greatest potential hazard (Fig. 7). Lake Ontario, excluding the Niagara River area, has more than 145 waste disposal sites located within 5 km of the shoreline, and this situation is made worse by the high incidence of permeable, sand soils in this zone. (Coakley)

Sediment/Contaminant Dynamics, Toronto Waterfront

The transport of contaminated fine-grained sediments from various point-sources in the Toronto area may pose a health hazard for local bathing beaches and water intakes. Cooperative studies (with Environmental Contaminants Division, NWRI; and the Ontario Ministry of the Environment) are underway that are aimed at determining the directional patterns and rates of fine sediment transport in this area. Bottom sediments have been sampled and analyzed for grain-size distributions and major trace elements. The aim of the analyses was to characterize the sediments and to identify naturally-occurring properties which might be useful for tracing sediment movement. Potential tracers presently being investigated are various low-solubility trace elements associated closely with heavily-industrialized watershed, antropogenic sediment particles, and bottom-sediment grain-size patterns. (Coakley)

Great Lakes Nearshore Sediment Data

Nearshore file data were supplied to Environmental Protection Service, Toronto (dredge spoil sites, Sarnia and Owen Sound; PCB study, Wheatley), Huntec Toronto (Geophysical equipment trials, Toronto area), the city of Port Colborne (local planning) and the US Geological survey (map compilation). Lake Ontario nearshore data were used in conjunction with lake basin data to select sites for the International Joint Commission (IJC) Lake Ontario Surveillance Program. A description of the nearshore database was requested by the Water Resources Branch for the Ontario Sediment Survey Program Review. Poster presentations on the structure and contents of the database were made at the Great Lakes Conference in Milwaukee and the Canadian Coastal Conference in St. John's. (Rukavina)

St. Clair River Survey

Hydrographic surveys of the upper St. Clair River and the tarry puddles site were carried out in mid-November, and existing core data were analyzed for grain size. A description of river morphology and sediment properties was prepared as a contribution to NWRI's St. Clair River report. (Rukavina)

Lake St. Clair Bottom Sediments (UGLCCS)

Work has begun on the compilation of data on the bottom sediments of Lake St. Clair. A trial of echo-sounding equipment was carried out in Lake St. Clair to determine the feasibility of sounding for measuring the thickness of the contaminated soft surface muds. (Rukavina)

Wave Dissipation in Shallow Water

In response to a need for better numerical forecasts of waves in shallow lakes and coastal zones, the National Water Research Institute, the Atmospheric Environment Service, and the Great Lakes Environmental Research Laboratory (NOAA) installed a network of six towers in Lake St. Clair (Fig. 8) to measure the growth of waves with fetch and to estimate the dissipation due to bottom friction. The towers were in place from mid-September to early December 1985 and returned an impressive data set. Computer programs have been prepared to analyze the wave records and the analysis is being carried out by NWRI, GLERL and AES. GLERL and AES both maintain operational wave models (based on the NWRI research model) on the Great Lakes and expect that the interpretation of this Lake St. Clair experiment will be useful in improving these models particularly for Lakes Erie and St. Clair and the coastal zones of the other lakes.

In addition, one tower was instrumented with transmissometers to detect sediment resuspension events and to correlate those events with

the wave activity. Preliminary tests were also conducted using mud from Lake St. Clair in a laboratory wave flume to gain an understanding of the sediment-wave interaction. (Donelan and Skafel)

St. Lawrence River Bottom-Sediment Surveys

A survey of the sedimentology and bathymetry of Lac St-Louis in the St. Lawrence River was carried out at the request of Inland Waters Directorate, Quebec Region, which is investigating the pollution of the St. Lawrence. Field work was carried out in cooperation with IWD, Quebec Region and the Quebec Region of the Canadian Hydrographic Service. A final report is in preparation. Planning is well-advanced for a similar survey of Lac St-Pierre during 1986. (Rukavina)

Measuring Waves with Pressure Transducers

Experiments to establish the veracity of linear wave theory in predicting wave heights from subsurface pressures were completed in the laboratory. Analysis of data is in progress. (Bishop, Donelan)

Minimum Wind Speed for Wave Generation

The 8 m cold-room flume was used to explore the effect of water viscosity on the formation and growth of wavelets in very light winds. A very sensitive laser slope gauge detected waves a few microns high for winds of 0.7 m/s but these waves were not discernible by eye until the wind was increased to about 3 m/s. The "critical" wind speed, where wavelike surface disturbances were readily discernible, was found to depend on water temperature (Fig. 9) through its effect on viscosity and hence rate of dissipation of the growing wavelets. Viscosity varies by about a factor of two over natural oceanic or lacustrine surface temperature extremes, so that these laboratory results are important in remote sensing of oceanic winds through microwave detection of short wind waves. (Kahma and Donelan)

Turbulent Mixing Beneath Wind Generated Waves

A field experiment has been designed to measure some aspects of the interaction between wind-generated waves and turbulence in the wind-driven surface layer. The experiment - in three phases over three years - is being conducted from the National Water Research Institute's offshore tower in Lake Ontario by scientists from both NWRI and Woods Hole Oceanographic Institution. (Donelan, Skafel and Kahma)

Bottom Erosion in the Nearshore Zone of Lakes and Reservoirs

Coastal erosion rates and the eventual limits of shoreline recession in natural and man-made lakes are closely dependent on the rate of bottom erosion in the nearshore zone. An important mechanism in bottom erosion is the action of shear stresses generated by the passing wave field. A field site was established in the Stoney Creek area of Lake Ontario to investigate these mechanisms in detail. For determining wave-induced shear stresses, two parameters - the friction factor and the bottom orbital velocity, are crucial. The first step in obtaining the former was the collection of a plaster cast of the natural till bottom at the site, through divers using a technique developed by Parks Canada archaeologists. Replicates of this cast were then placed in a flume in the Hydraulics Laboratory (Fig. 10) to determine the equivalent roughness coefficient, a parameter directly related to friction factor.

The wave field at the site was obtained from hindcasts of the wind record at Toronto Island Airport. Values from shear stress corresponding to the various wave frequencies were then calculated for areas of the profile composed of bare till by substituting the wave orbital velocities and friction factor into the shear stress equation. Shear stresses reached as high as 6.4 Pa for waves 4 m high and with periods of 10 seconds.

Critical shear stress, i.e., the level of shear stress at which erosion of the surface is first noted, was measured by Zeman on samples

from the same area. Zeman also quantified the relationship between shear stress applied to the samples in the laboratory, and the mass erosion rate. This relationship is now being tested in connection with the field-derived stress distribution to predict bottom erosion rates, using direct measurements of bottom erosion by Rukavina as a check. For the moment, it is clear that the shear stress levels obtained from the wave-related calculations are above critical values a significant portion of the time. This finding confirms our view that such stresses, acting alone or in combination with other processes, are capable of causing considerable erosion at depth. (Coakley)

Subaqueous Erosion, Lake Ontario

Frames with fixed-transducers were reinstalled at five stations along the profile line at Stoney Creek, and bottom elevation was monitored acoustically and by dives from April to December 1985. Changes from the December 1984 data were observed in the inshore stations where a mobile sand cover was present, but offshore elevations in the area of exposed till were the same as those previously recorded. (Rukavina)

Erodibility of Cohesive Sediments

Laboratory erodibility tests, using the rotating-cylinder apparatus developed at the National Water Research Institute, were carried out to determine the erosion resistance of undisturbed cohesive tills from bluff-type shores of Lake Erie and Lake Ontario.

The results indicate that the method can be used to distinguish erosion resistance of different till formations both in terms of the critical shear stress and the erosion rates. The results are presented in a joint paper on subaqueous erosion at the Stoney Creek site in Lake Ontario (Coakley, Rukavina, Zeman) and in another paper concerned with the erodibility of Lake Erie tills. Both papers will appear in the Proceedings of the Symposium on Cohesive Shores.

In connection with this research, new laboratory tests with the rotating-cylinder apparatus have been performed to determine the effect of surface roughness on the standard sand-roughness scale. (Zeman)

Van Wagner's Beach Study

All sounding records from a profile at Van Wagner's Beach, Burlington, Ontario, have been digitized at points where fixed-transducer or diver elevation were available. Results for the period 1980-82 will be analyzed to determine the effects of storms and seasonal water-level changes on the profile form. (Rukavina)

Coastal Sediment Budget, North-Central Shore of Lake Erie

A new sediment budget (Fig. 11) has been prepared for the study area, including implications with respect to the long-term sedimentation and erosion, and the role that harbour structures have played in the recent past. New information has been obtained on the erosion rates of the nearshore till shelf. The results are presented in an unpublished report and the manuscript has been submitted to the Journal of Great Lakes Research for possible publication. A poster display of the results has been prepared for the Symposium on Cohesive Shores. (Rukavina, Zeman)

Waves and Wave Forecasting

A section on waves and wave forecasting has been written for a new Handbook of Civil Engineering to be published in 1986. Topics include small amplitude wave theory, wave processes, wave measurement techniques, analysis of wave data, wave statistics and confidence limits, and wave prediction methods. This is presently available as an NWRI report. (Bishop, Donelan)

Wave Attenuation by Rough Walls

Experiments have been conducted in a wave flume to investigate the scale effects of modelling wave attenuation by lining harbour entrances with riprap (Fig. 12). Placing rubble at side slopes of 1.5 or 2 to 1 on vertical entrance channel walls is a technique used more and more to correct wave agitation problems in harbours and/or to correct structural problems at the walls. Wave height attenuation was found to be proportional to the wave height raised to the power 1.36, and was found to be inversely proportional to the water depth (d) raised to the power 0.36 and to the channel bottom width (w). The proportionality factor was found to vary with d/gT^2, w/d and side slope (where T is the wave period and g is the acceleration due to gravity). (Bishop)

Wave Loads on Submarine Pipelines

Wave loads on submarine pipelines are normally predicted using the Morison equation which uses empirically determined drag and inertia coefficients. Values which should be assigned to those coefficients remain very uncertain. In northern locations, where pipelines may be laid in open trenches to avoid ice damage, little or no data exists. A series of laboratory tests has been planned to determine the drag, inertia, and lift coefficients for pipelines in trenches. The pipeline test setup has been designed and manufactured. Details of the flow field will be examined with a laser-doppler anemometer. This work is partially funded by the Panel on Energy Research and Development. A report reviewing literature on wave forces on submerged pipelines is available as an NWRI report. (Skafel, Bishop).

Symposium on Cohesive Shores

During the fiscal year, preparations were underway to organize the Symposium in early May 1986, with scientific and engineering participation from Canada, U.S.A. and Great Britain. The Symposium was sponsored by the Associate Committee on Shoreline Erosion and Sedimentation (ACROSES) of the National Research Council Canada and organized by the Shore Processes Section in cooperation with several external participants. The program included two days of technical sessions and a one-day field trip to the Toronto waterfront. The Symposium dealt with geomorphic, geotechnical and hydraulic processes active on bluff-type shores, numerical and physical modelling of shore and subaqueous erosion, innovative methods of shore protection and management strategies. The proceedings of the Symposium will be published in 1986. The subject of the Symposium attracted considerable interest because of the current lake levels in the Great Lakes region that are at record or near record heights and that are reponsible for accelerated shore erosion. (Zeman)

CCIW Open House, 1985

A videotape on local beach changes and a computer quiz on shoreline facts and issues were presented as Open House displays in April. (Rukavina)

TECHNICAL SERVICES SECTION

An increase in technical support was noted to assist scientists with their field studies, in particular, the ice jams and floods study, the urban runoff study, and the mobile bed river flow study, as well as the annual support to the Divisional geologists.

The Section staff enjoy a certain amount of field work and most support staff participated in these activities. Two visiting scientists also received some technical assistance, all of which made the assignments of technical staff to studies more challenging.

The request for current meter calibrations increased slightly over the previous year, and the data acquisition system which collects towing tank calibration data was upgraded. In the Sedimentology Laboratory, the newly acquired Sedigraph was computerized.

As activities increase and financial resources remain limited, it is becoming more difficult to keep the laboratory and its unique facilities in good operational condition. We have managed this far and we will continue to manage thanks to the expertise, cooperation, and dedication of the Section staff.

Laboratory Services

Technical staff provide support to scientists and engineers conducting basic and applied research in the Hydraulics Laboratory and related field projects.

A marked increase of field support was provided for the frazil, anchor ice, ice jams and flood studies. Support was also provided to third parties under the Department's cost recovery policy.

Tests to determine the head loss through various components of an automatic sediment sampler were done for the Water Survey of Canada.

The Sedimentology Laboratory classifies sediments by their particle size and determines organic and total carbon in sediments. The geotechnical laboratory undertakes tests of soils as a structural material.

These laboratories provide support for Institute projects as well as other government agencies, universities and the private sector. Cost recovery is used.

A new sedigraph was purchased which will be computerized to provide a more accurate and efficient service; modifications have also been made to the settling tube.

Summary of tests and analysis performed during this fiscal year:

		85/86
Particle size analysis	- NWRI	1471
	- Universities	150
	- Private Sector	53
Carbon analysis	- NWRI	4050
Sediment separation	- NWRI	76
Geotechnical tests	- NWRI	7

The laboratories are provided with expert trade support such as carpentry, light machining, and electronics. Supervision is also provided when contractors are working in the laboratory, performing maintenance repairs or constructing experimental setups. Consultation is provided to scientists and engineers on construction problems.

Inventory and procurement of materials and supplies were also undertaken. Advice on equipment and facility design, as well as electronics and mechanics to the many users of the Hydraulics Laboratory, was provided by a group of highly qualified technologists.

A laminar flow flume was constructed for studies on meander formation and a frazil ice flume was constructed for laboratory testing of the frazil ice instrument.

National Calibration Service

The tow carriage microcomputer data acquisition system has now been in daily operation for over two years. A more powerful 16 bit computer has been procured to improve operations.

A very high accuracy calibration program for Hydro-Québec was completed under a cost recovery agreement involving the calibration of 65 SIAP current meters which will be used for turbine efficiency measurements. This special calibration required 48 different velocities and 12 to 14 hour days to complete the run.

At the request of Sediment Survey Section, Water Survey of Canada, plans were prepared to have WSC's entire inventory of suspended sediment samplers checked, repaired and calibrated. This work will be completed over a two-year period after which each sampler will be recalled for recalibrations every two years.

The use of the towing tank to calibrate current meters and to perform special tests on hydrometric equipment is broken down as follows:

	% Time Used
Water Survey of Canada	35.1
Other Federal Agencies	25.3
Provincial Governments	14.9
Universities	5.9
Hydro Companies	8.4
Consulting Engineering Firms	10.4

ENGINEERING SERVICES SECTION
HIGHLIGHTS

Water research and management studies often require unique and sometimes complex measuring and sampling systems and equipment for their successful progress.

The Engineering Services Section does the system planning and design required to develop such equipment for NWRI clients and others authorized by the Director, National Water Research Institute. These services include:

- Project management for the design, development, construction, and testing of sampling and measuring equipment.
- System and equipment layout, evaluation and trade-off for selection of best design approach.
- Engineering design, specification, and drawing for development and manufacture of prototype equipment, instruments, and systems.
- Technical consulting services, including bid assessment, equipment tests and evaluation, design review.

The Section is also actively involved in the transfer of technology to the public domain by publication, participation in seminars and conferences, and through the Departmental Program for Industry/Laboratory Projects (PILP).

REPORT ON INDIVIDUAL STUDIES

Mini Surface Sampler

A smaller model (Fig. 13) of the rotating drum surface sampler was designed and constructed for Environmental Contaminants Division, NWRI. This new device, based on the success of our earlier design, is reduced

in size and complexity to make it compatible with car top size boats used in small and isolated water bodies. The drum may be driven by hand, or a battery driven motor with speed control may be fitted for this purpose. The unit was delivered for field work in the late summer of 1985. Some minor modifications including the addition of the electric drive were made over the winter, and the unit was available for spring deployment. (Madsen)

WAVES '86

WAVES '86 is a three-year collaborative study with scientists from the Woods Hole Oceanographic Institution. It is a field investigation into the processes of white capping and wave turbulence interaction, and uses the NWRI Research Tower as the base for observations.

A Data Acquisition System was designed and constructed to make the required observations. This system was required to record up to 48 channels of information at 20 Hz in continuous seven hour episodes. A significant project management input was provided to coordinate the efforts of Engineering Services Section, Manufacturing and Technical Development Section, and Technical Operations Division in designing and constructing this system and setting it up and supporting its operation on the tower for three months in the fall, 1985. Major sensor arrays were also developed, including a dynamic air pressure array capable of sensing air turbulence in the frequency band from about .02 to 1.5 Hz. (Desrosiers)

Waves Dissipation Study

A set of six portable 10 m towers were placed on the bottom of Lake St. Clair as wave height recorder stations, in support of a field experiment to measure wave dissipation characteristics in shallow lakes. This was a joint experiment with NOAA/Great Lakes Research Laboratory.

Design requirements for the towers were that they be portable and relatively easily assembled on shore, and that they be installed from a barge using a crane, with no diver support for later instrument installation.

Three towers were used by NOAA/GLRL, and three by NWRI. The NWRI towers were fitted with a data logger and sensors for wave height and wind measurement. One of the towers had an additional data logger and sensors for water transmittance and wave pressure.

Equipment installation was completed by mid-October, and operated until removal in early December 1985. (Roy, Pedrosa)

Compaction Mould

Studies of erodibility of littoral and fluvial soils requires that the moisture content of the soil sample be controlled at the start of erosion measurements.

A soil sample compaction system was designed and built. It comprises a mould to form the compacted sample to specific dimensions and a 25 tonne compression machine capable of producing a mould pressure of 27 MPa. The compression machine drive was modified to provide a constant mould pressure as the soil sample is loaded or squeezed to obtain the required moisture content. (Madsen)

Suspended Sediment Sensor Development

Design and development continued on an improved suspended sediment sensor system with Hydraulics Division replacing the Scientific Equipment Development Working Group (SEDWG) as sponsor. A data acquisition micro-computer and some sensor hardware were purchased. The light scattering calculation algorithm was completed and tested. This algorithm will now permit calculations to be made for evaluating effects of changes to instrument or sensor design characteristics, such as field of view, spectral response, and particulate size distribution on proposed instrument output signal levels or sensitivity. (Desrosiers)

Ice Jam Profiler

Field studies of ice jams could be improved if it were possible to obtain some measure of the jam's underwater profile.

A proposal was made to measure this profile using a pressure sonde with a tracking radio system to obtain depth and X-Y position under the ice jam.

A two-dimensional mathematical model of the pressure sonde's track under the ice jam was developed to assess the effects of change in the sonde configuration (Fig. 14). An optimal configuration was identified for scale model flume tests as a further assessment of the feasibility of this idea. (Ford)

Frazil Ice Recorder

The development of the Frazil Ice Recorder was continued. The system was deployed for five weeks at the Ontario Hydro Sills Island Hydropower Generating Station on the Trent River with some success. A presentation on this development was made at the 4th Workshop on the Hydraulics of River Ice. The prototype has been further tested in the Hydraulics Division cold room flume to gain further operational experience. Minor design changes are being evaluated, and the prototype is being prepared for deployment by Inland Waters Directorate/Atlantic Region in their river ice study program. (Ford)

Scientific Equipment Development Working Group (SEDWG)

Engineering Services continued to work with SEDWG, the NWRI Scientific Equipment Development Working group, towards the development and evaluation of equipment for future research applications.

A 2 MHz power supply to drive a nebulizer for preparation of spectroscopy samples was designed and built. The equipment comprises an oscillator, power amplifier, and impedance matching circuit to drive the crystal transducer of the nebulizer.

Two Hydrolab Data Loggers with an Interregator interface were purchased for evaluation with possible application to stream monitoring. Functional tests were done, some faults were found, and the units were returned to the supplier for repair and recalibration. Upon return, the units will be operated in the field environment. The experience has been useful in assessing the state-of-the-art in commercially produced hardware, as well as improving scientific user's knowledge of equipment.

Field evalution tests were completed on the Solid State Temperature Logger developed inhouse. Five prototype units were placed in common user inventory for field service.

Consulting

Consulting services are being provided to Inland Waters Directorate/Water Survey of Canada in the form of monthly review of design data received on an Acoustic Streamflow Meter Contract.

Functional tests were carried out on a SeaStar *in situ* water sampler for IWD/Water Quality National Laboratory.

Support to evaluation tests and calibration of an Interocean S-4 spherical electromagnetic current meter was provided to Carl Anderson of Bedford Institute of Oceanogrpahy, Department of Fisheries and Oceans.

Program for Industry-Laboratory Projects (PILP

PILP is the interdepartmental program for stimulating and financially assisting the transfer of technology from federal government research laboratories to Canadian Industry with the aim of eventual commercialization.

PILP activities at NWRI are coordinated by the Engineering Services Section. Equipment for which Contribution Arrangements are in effect are the multi-band transmissometer (Moniteq Ltd.), which will be field tested in July 1986, the solid state temperature logger (Metrex Instruments Ltd.), and the light weight corer (Questa Engineering Ltd.). (Roy, Ford, Desrosiers)

MANUFACTURING AND TECHNICAL DEVELOPMENT SECTION

The Section provides electronic and mechanical design and manufacturing services of prototype limnological instrumentation, and the calibration of instrumentation systems for the scientific and engineering studies of the National Water Research Institute and studies of other Branches at the Canada Centre for Inland Waters.

During the period the Section's manpower was reduced to 10.25 person years, however, with the assistance of contracted-in manpower, the Section provided 13.04 person years of service to the clients (Table 1). The contracted-in manpower was primarily electronics technicians of which the Section is vastly understaffed to meet the demands of the clients (Table 2).

There were 843 work order requests during the period. The NWRI accounted for 682 work orders and the remaining 161 were requests by other clients at the Centre. This is an overall increase of 17% from the previous year. This overall increase was heavily weighted by an increased demand for electronics assistance to clients of 32% over the previous period (Table 3).

The various systems and equipment that the Section developed were in support of other groups. These items are reported elsewhere in this report by the Engineering Services Section, Environmental Hydraulics, Section, Shore Processes Section, and other NWRI and non-NWRI clients.

TABLE 1

MANTEC - PERSON YEAR
ACCOUNT SUMMARY
FY 85/86

Client	Allocation	Used	Difference
Director's Office	0.42	0.61	0.19
Environmental Contaminants Division	0.50	0.71	0.21
Hydraulics Division	2.04	4.21	2.17
Aquatic Ecology Division	0.99	1.10	0.11
Aquatic Physics and Systems Division	0.75	0.92	0.17
Analytical Methods Division	0.20	0.13	(0.07)
Technical Operations Division	0.55	0.74	0.19
Staff Services Division	0.02	0.05	0.03
Water Quality Branch, Ontario Region	0.10	0.18	0.08
Environmental Protection Service	0.15	0.08	(0.07)
Great Lakes Fisheries Research Branch	0.10	0.06	(0.04)
Department of Fisheries and Oceans	0.20	0.17	(0.03)
Water Quality National Laboratory	0.12	0.15	0.03
Others	0.03	0.12	0.09
Water Survey of Canada - Guelph	0.00	0.07	0.07
Engineering Services Section	1.10	0.75	(0.35)
Manufacturing and Technical Services Section	3.83	2.99	(0.84)
	11.10	13.04	1.94

TABLE 2

MANTEC COST RECOVERY
ON-SITE CONTRACT MANPOWER
FY 85/86

Client	Funds	PY	Category
Aquatic Physics and Systems Division	5,976.95	0.16	EL
Aquatic Ecology Division	6,700.00	0.17	EL
Hydraulics Division	37,928.65	1.36	EL/GLT/DD
Water Quality Branch, Ontario Region	2,803.00	0.07	EL
Water Quality National Laboratory	868.12	0.02	EL
Water Survey of Canada - Guelph	3,900.00	0.09	EL
Manufacturing and Technical Services Section	7,300.00	0.28	EL/GLT
	65,476.72	2.15	

TABLE 3

MANTEC WORK ORDERS
DISTRIBUTION BY CLIENT

Client	Electronics	Mechanical	Calibration	Machining	Total
Director's Office	6	9	3	8	26
Environmental Contaminants Division	12	13	5	25	55
Hydraulics Division	76	56	40	58	230
Aquatic Ecology Division	21	23	5	22	71
Aquatic Physics and Systems Division	29	16	13	17	75
Analytical Methods Division	6	5	5	9	25
Technical Operations Division	-	8	23	46	77
Staff Services Division	5	3	2	6	16
Water Quality Branch, Ontario Region	2	9	1	21	33
Environmental Protection Service	1	0	2	17	20
Great Lakes Fisheries Research Branch	0	3	4	6	13
Department of Fisheries and Oceans	0	5	3	37	45
Water Quality National Laboratory	6	4	9	7	26
Others	1	7	11	5	24
Engineering Services Section	36	19	23	29	107
Total	201	180	149	313	843

DRAFTING SERVICES SECTION

This Section provides drafting and illustrating support by undertaking graphics and visual presentations, technical and scientific illustrations as well as cartographic, mechanical and electronic drawings of a quality suitable for publication.

This Section also provides a photographic service which includes photography of engineering and scientific research equipment, overhead projection material and slides for conferences and seminars and provides through outside sources, the requirements for type compositing, printing, reprographic, and photo-finishing services.

The Section maintains files of all original drawings, illustrations, and negatives of all photographs and reprographics. This service is provided for the Divisons of the National Water Research Institute and for all other Directorates, Branches and Services within the Canada Centre for Inland Waters.

OFFICE SERVICES SECTION

This Section provides office services, word processing, and clerical and record keeping support to all sections of the Divisional operations. Office Services manages the orderly production and distribution of reports and publications on scientific and engineering subjects, implementing the bilingual publishing policy of the Department of the Environment, and ensuring the communication of new information and knowledge to all sectors of society in Canada.

Office Services maintains a permanent file of research and technical reports. The Section responds to requests for reprints or copies of unpublished manuscripts. Statistics on requests for reports are kept.

Requests for Reports and Publications

The major product of the Division is new scientific or engineering information which is usually recorded by publication in journals or Departmental reports. Previews of research results are distributed to colleagues and management by means of unpublished reports. The Division maintains an open file on all research reports so that, if copies are not available from stock, a duplicate can be made through a convenience copier.

The usefulness of and interest in a piece of scientific work is difficult to measure. One possible yardstick of interest is to record the number of unsolicited requests made by telephone or in writing. A record of requests has been maintained since 1976 which gives some idea of the demand for the scientific work.

Table 4 shows the recorded statistics. Detailed analysis is probably not justified but a number of conclusions can be made:

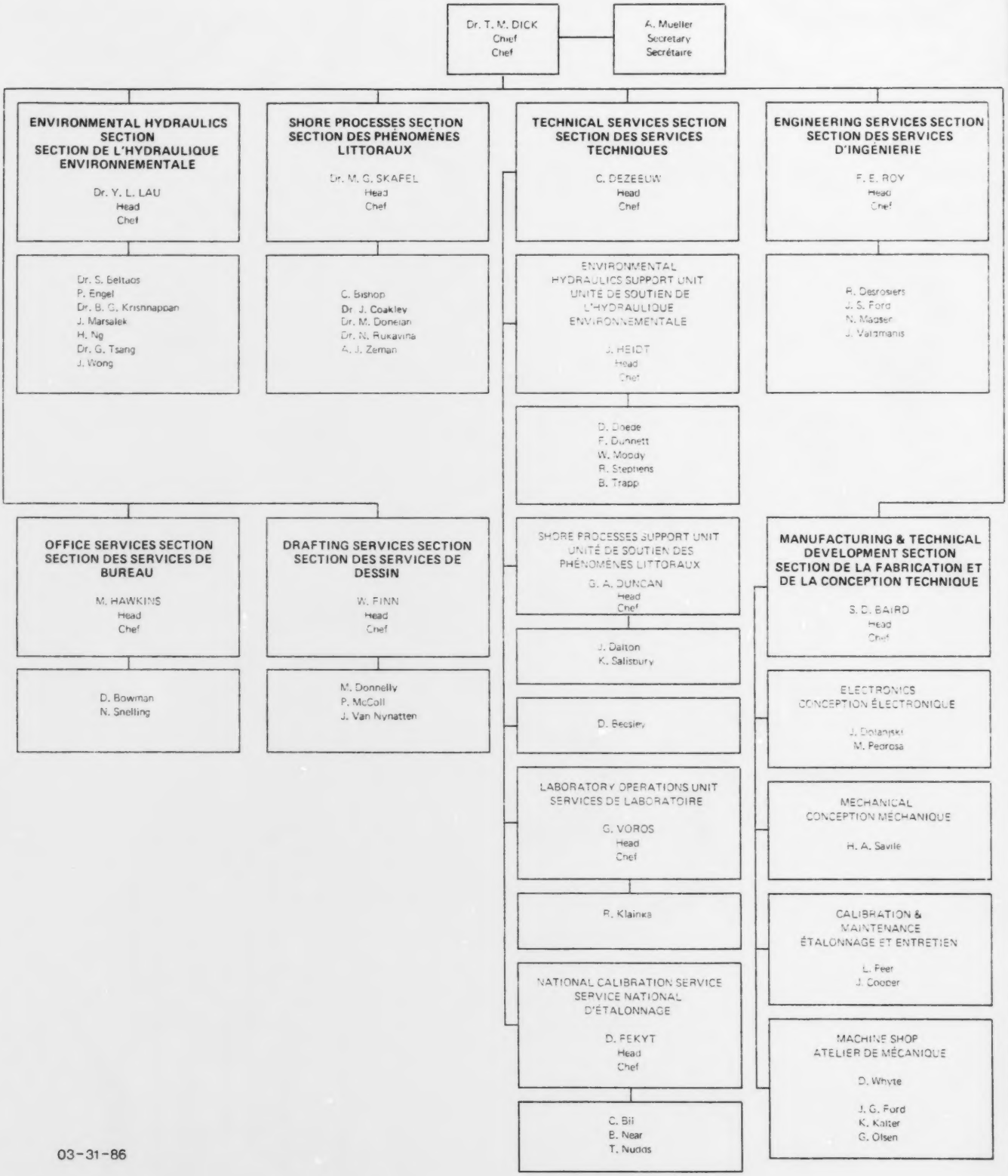
(i) In fiscal year 1985-86, approximately 800 reports have been distributed, or an average of 15 reports per week.
(ii) There has been an increase of requests from the provinces.
(iii) Requests from foreign governments have substantially increased.

TABLE 4

Requests for Publications Made Directly to the Hydraulics Division

Year/Location		Government			Universities	Private Sector	TOTAL	GRAND TOTAL
		Federal ECS	Other	Provincial				
1976	Canada	27	33	40	52	31	183	304
	Outside Canada		27	5	68	21	121	
1977	Canada	57	80	80	79	188	484	601
	Outside Canada		36	4	39	38	117	
1978	Canada	69	49	41	149	38	346	529
	Outside Canada		19	6	120	38	183	
1979	Canada	88	34	41	79	151	413	593
	Outside Canada		39	6	130	25	180	
1980	Canada	89	99	83	98	91	460	664
	Outside Canada		39	25	85	55	204	
1981	Canada	83	87	34	154	120	478	766
	Outside Canada		46	11	199	32	288	
1982	Canada	78	69	79	103	144	473	910
	Outside Canada		140	16	182	99	437	
1983	Canada	100	75	137	43	134	489	842
	Outside Canada		226	34	55	38	353	
1984-85	Canada	123	88	61	148	225	645	1003
	Outside Canada		161	11	145	41	358	
1985-86	Canada	83	47	86	101	117	434	796
	Outside Canada		207		77	78	362	

HYDRAULICS DIVISION
DIVISION DE L'HYDRAULIQUE



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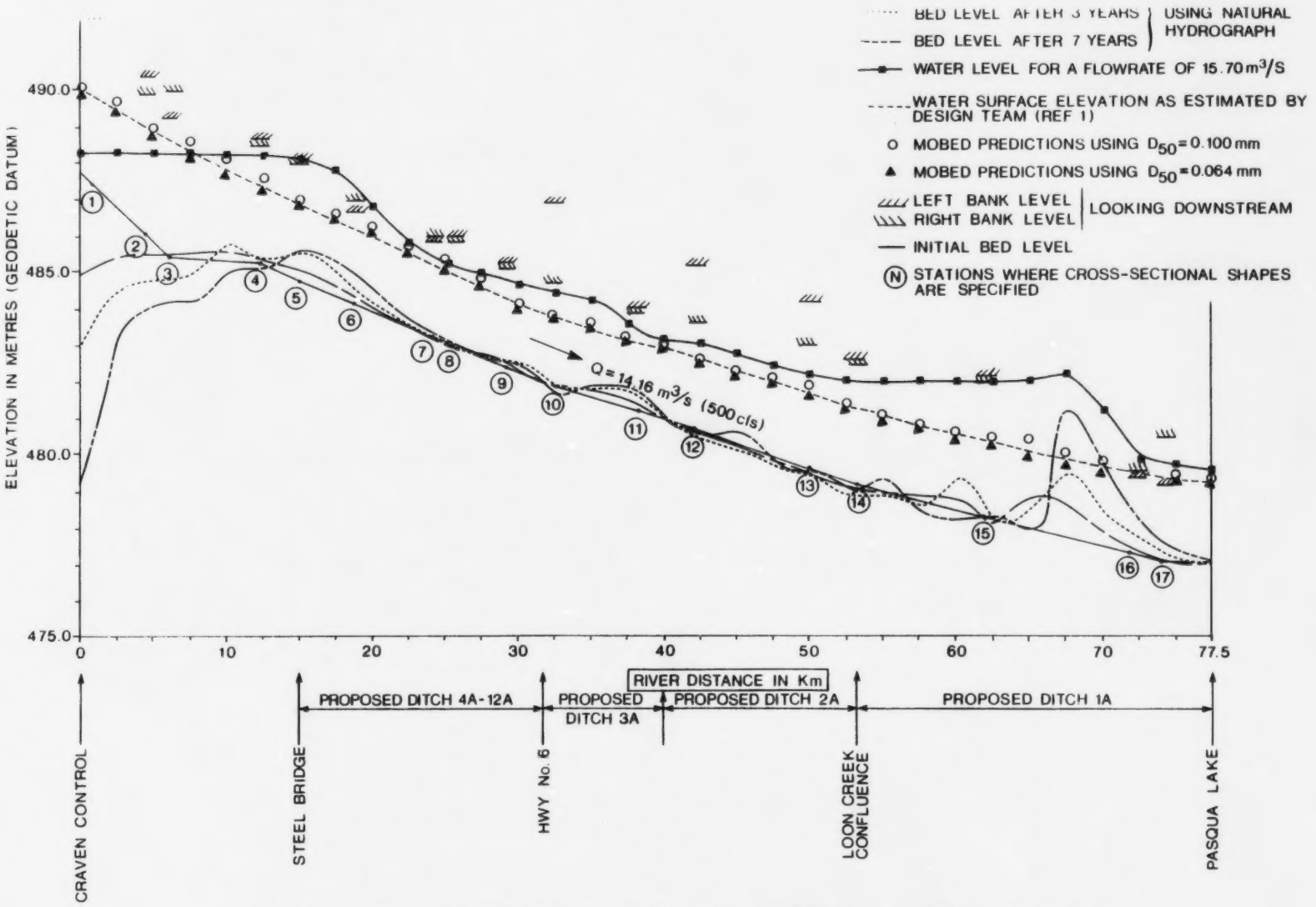


Figure 1 Variation of bed levels as predicted by MOBED for the Qu'Appelle River between Craven and Pasqua Lake using natural hydrograph.

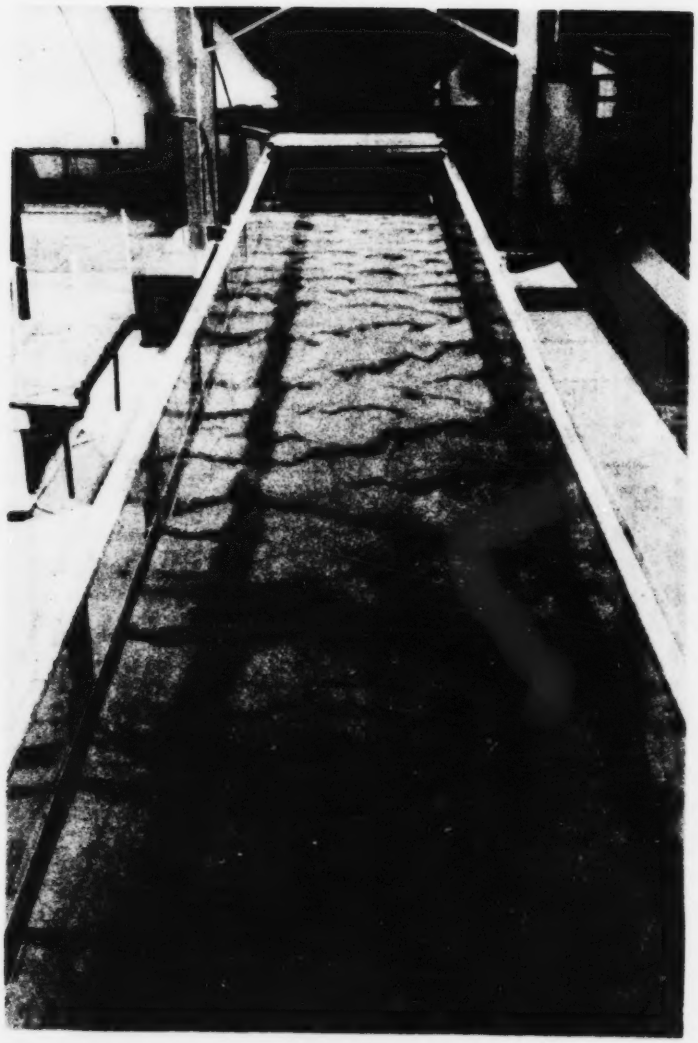


Figure 2 Dune bed in large sediment flume.

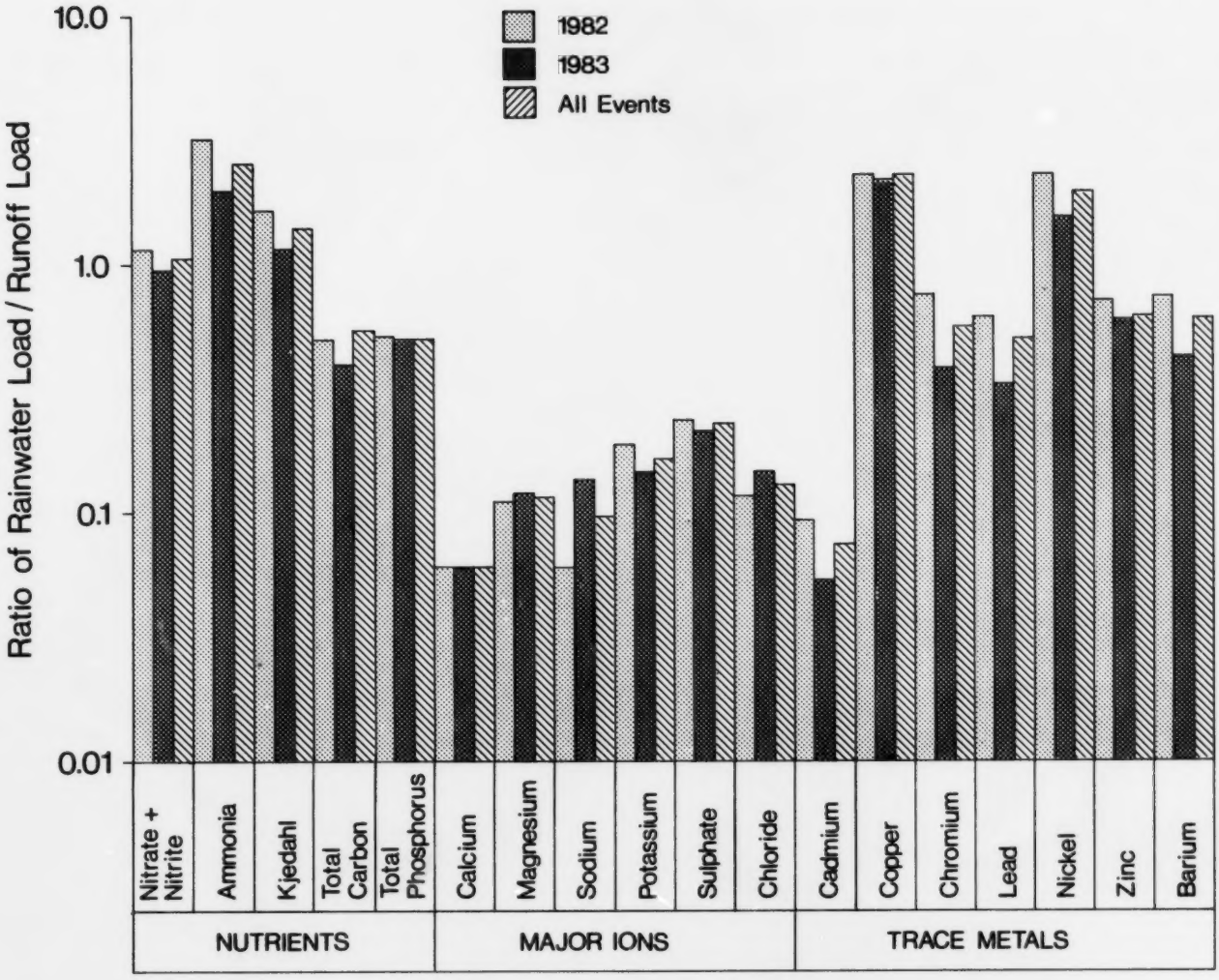


Figure 3 Ratio of rainwater load to runoff load.

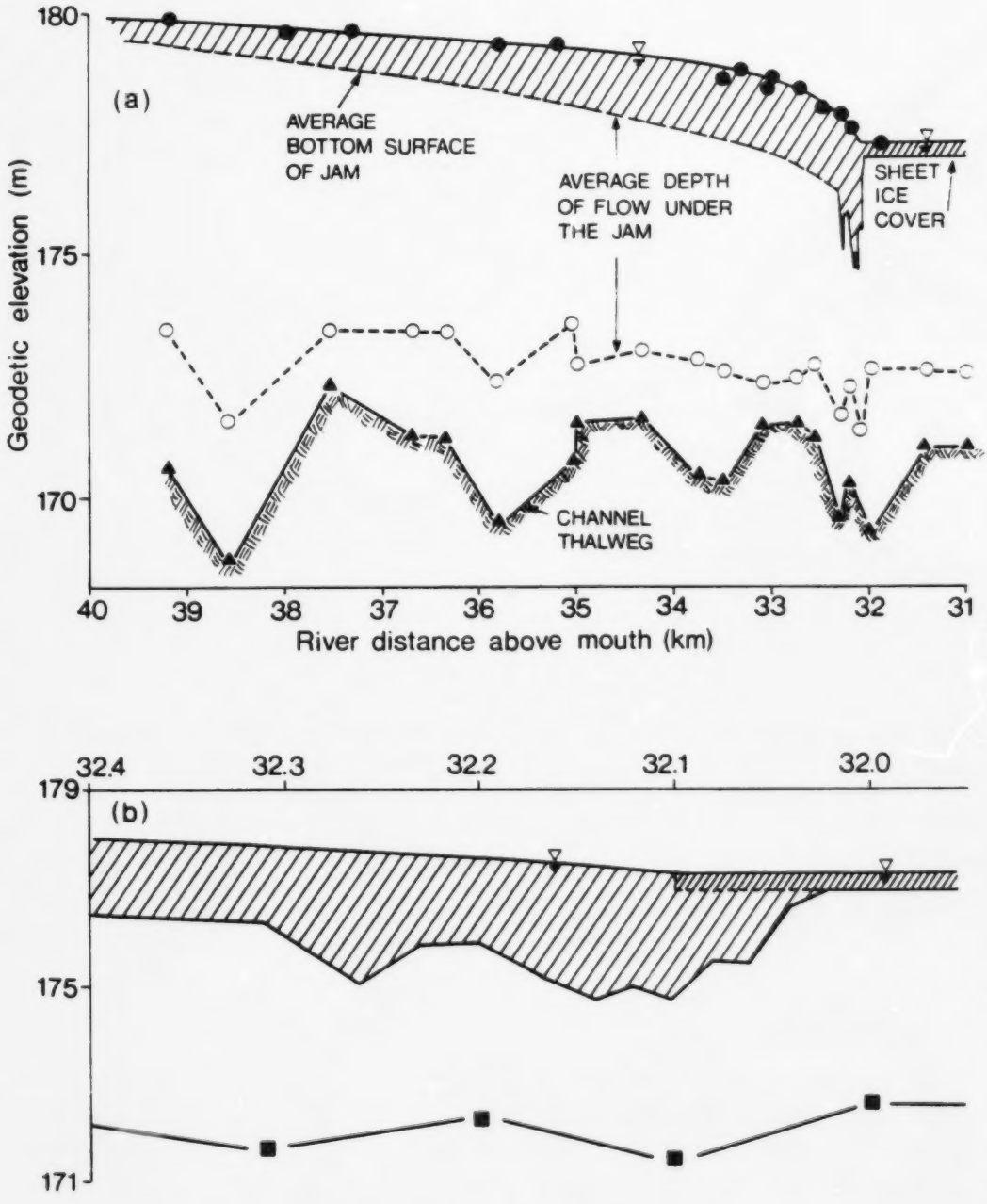


Figure 4 Profile of ice jam in Thames River above Chatham, Jan. 23, 1986. (a) complete profile; (b) toe configuration. Average river width ≃ 80 m.

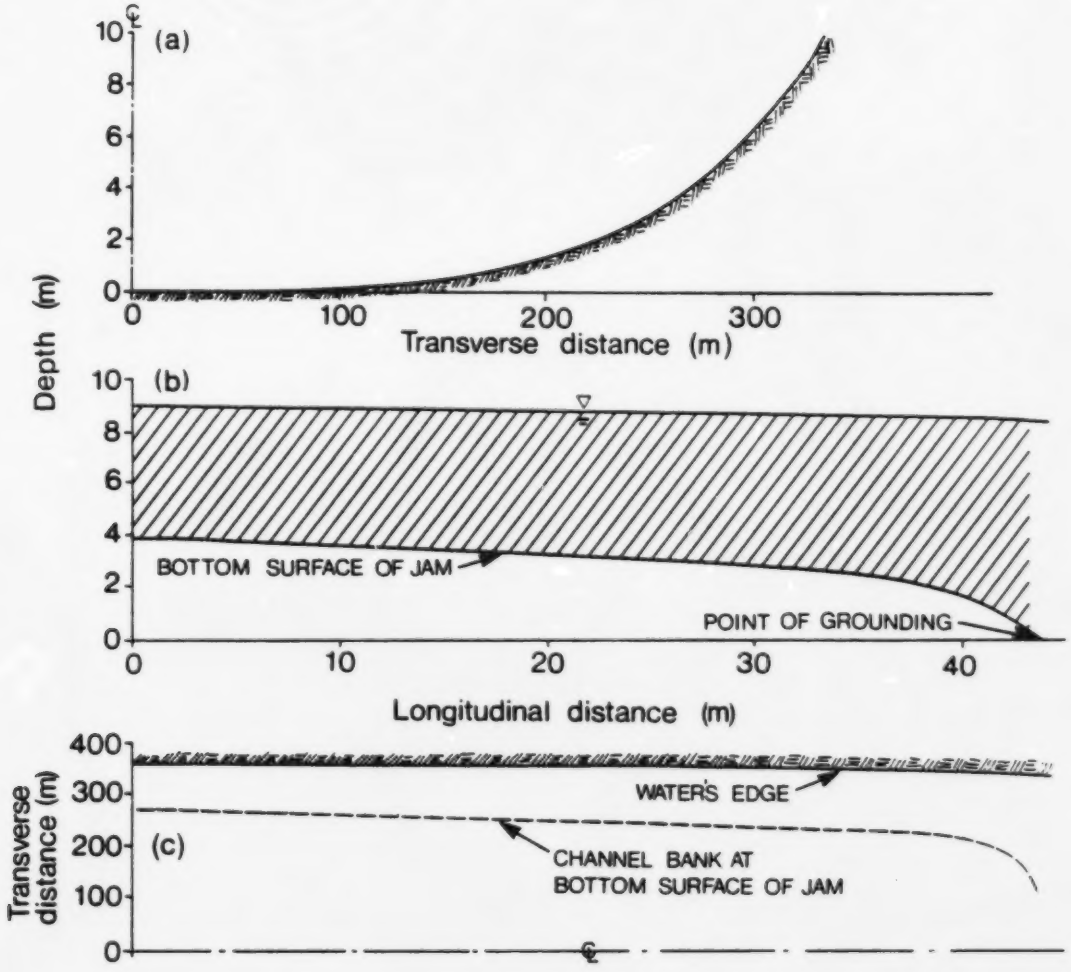


Figure 5 Computed configuration of an ice jam in a prismatic, non-rectangular channel. (a) Assumed channel cross-section; (b) longitudinal profile near toe; (c) channel plan view. Width $\simeq$ 700 m, slope = 0.00036, discharge $\simeq$ 1100 m^3/s.

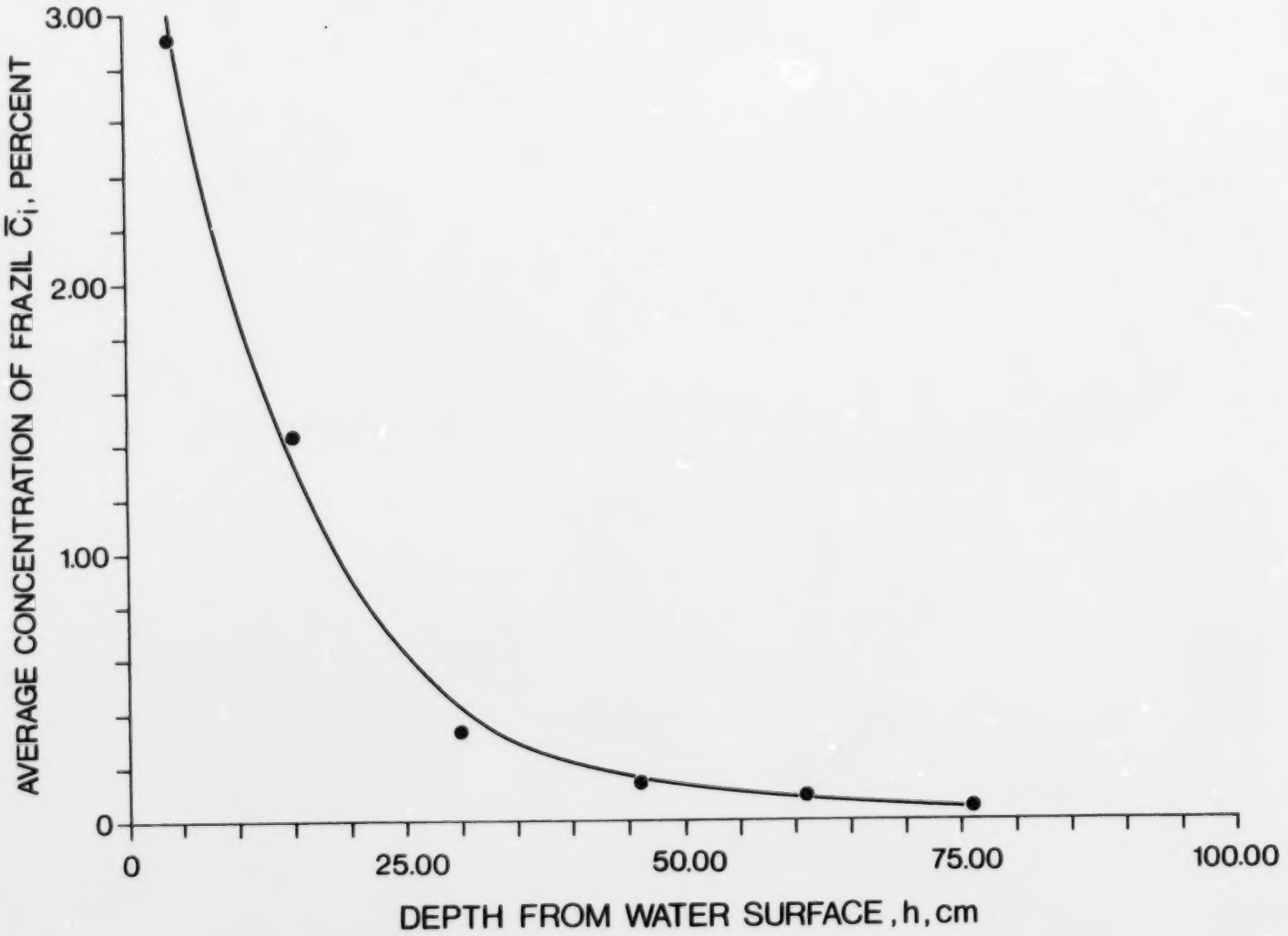


Figure 6 Distribution of frazil as a function of depth.

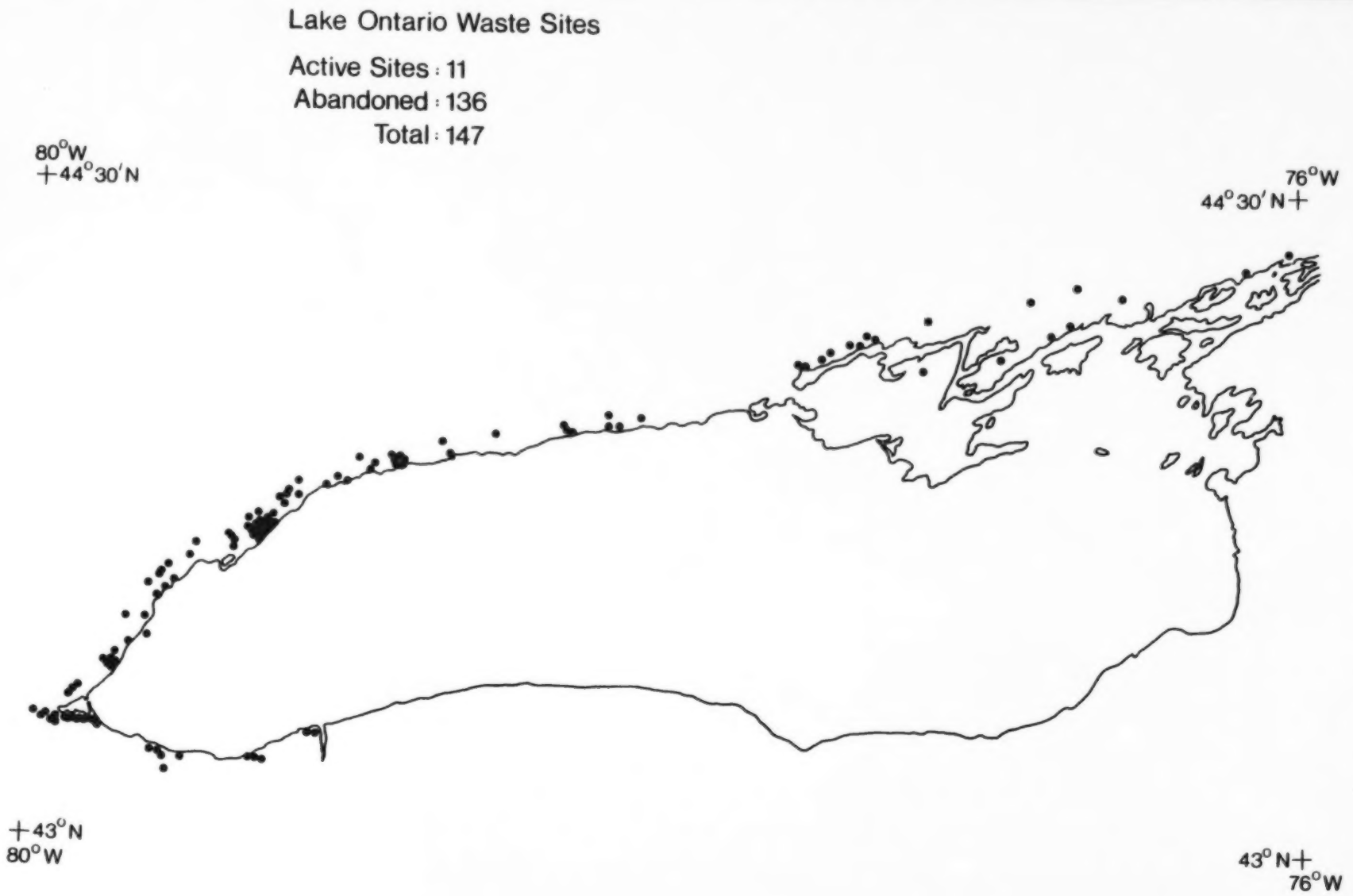


Figure 7 Lake Ontario has the largest number of waste disposal sites within 5 km of the shoreline.

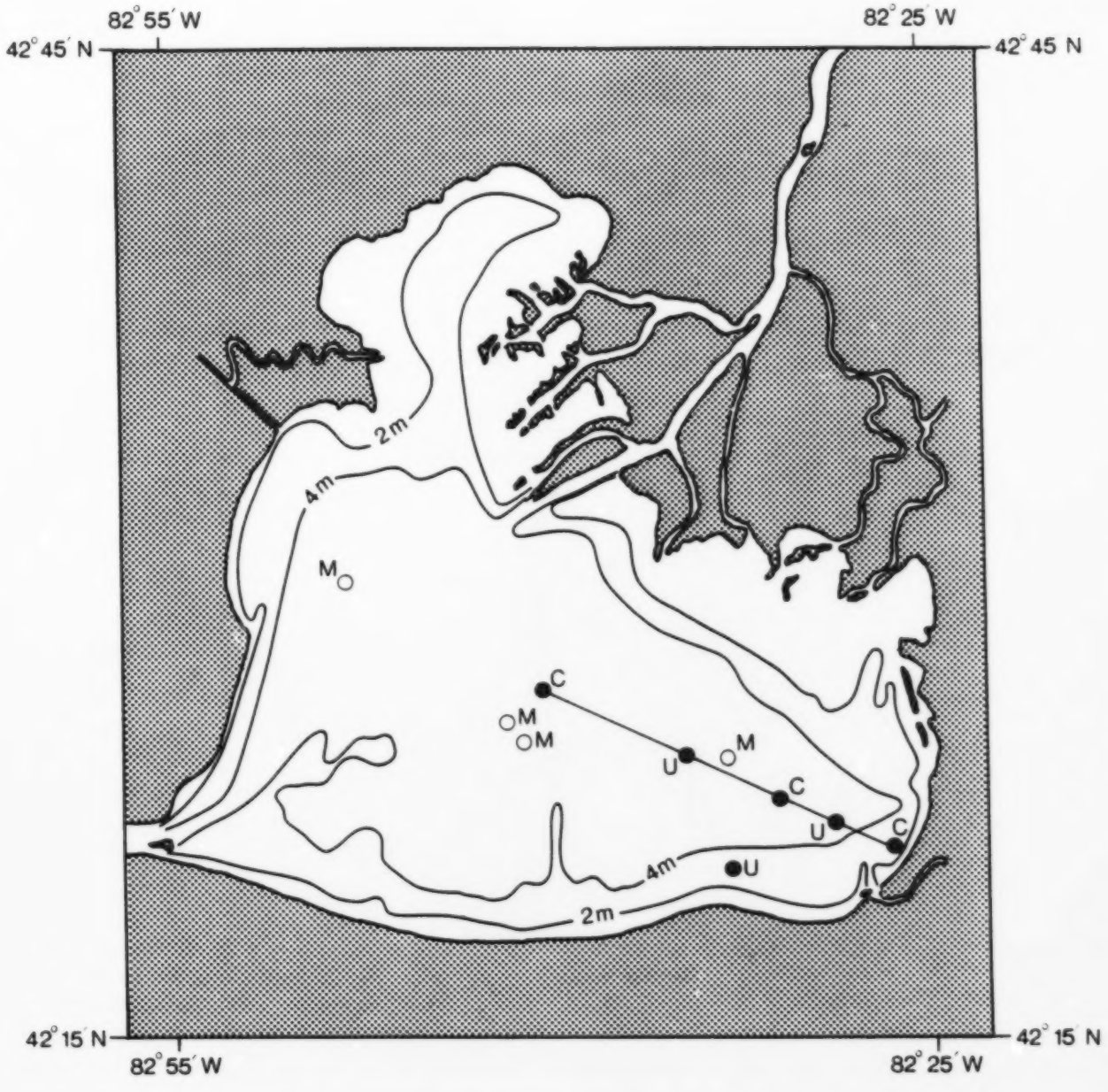


Figure 8 A map of Lake St. Clair showing the depth contours and the location of the six (U = U.S., C = Canadian) wave measuring towers and the four meteorological buoys (M). The array of wave towers was designed to explore the wind-induced growth and bottom-induced dissipation of waves in shallow water.

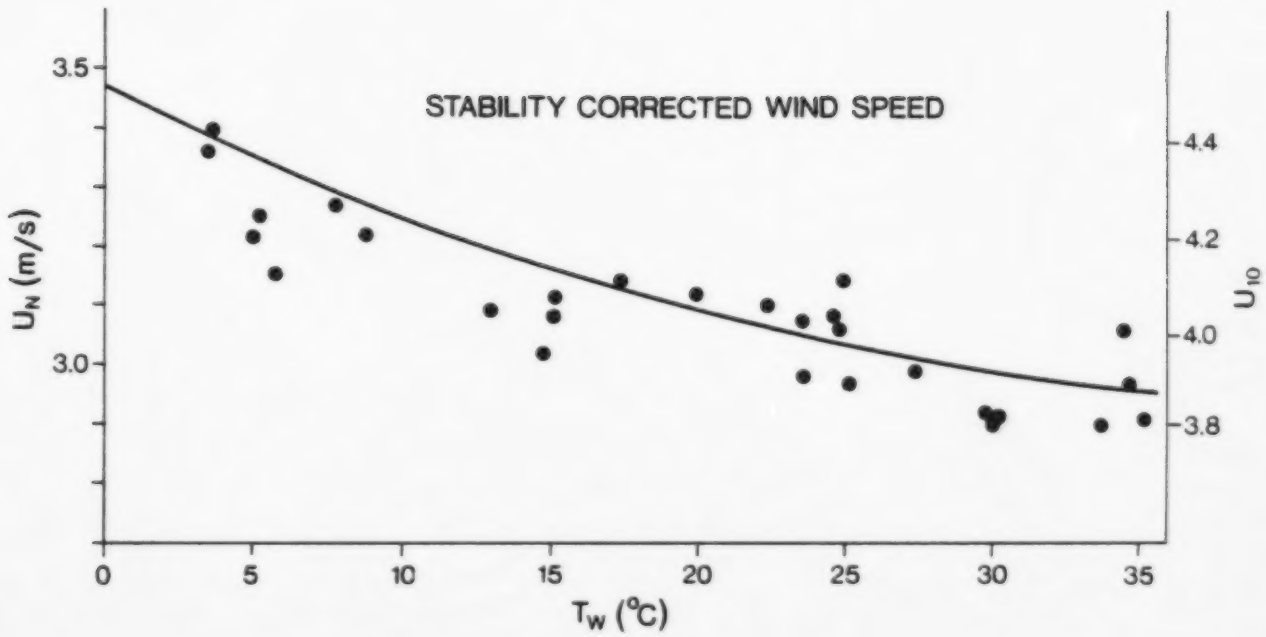


Figure 9 The "critical" speed, at which the water surface first becomes distinctly wavy at a fetch of 4.5 m, versus water temperature. The wind speed shown is the stability corrected (equivalent neutral) wind speed. The decrease in critical wind speed with increasing water temperature occurs because of reduced water viscosity and hence reduced damping of the initial wavelets, so that they form at a lower wind speed the lower the water's viscosity or the higher its temperature.

Figure 10 Testing of plaster casts simulating the natural till bottom in the 0.6 m recirculating flume.

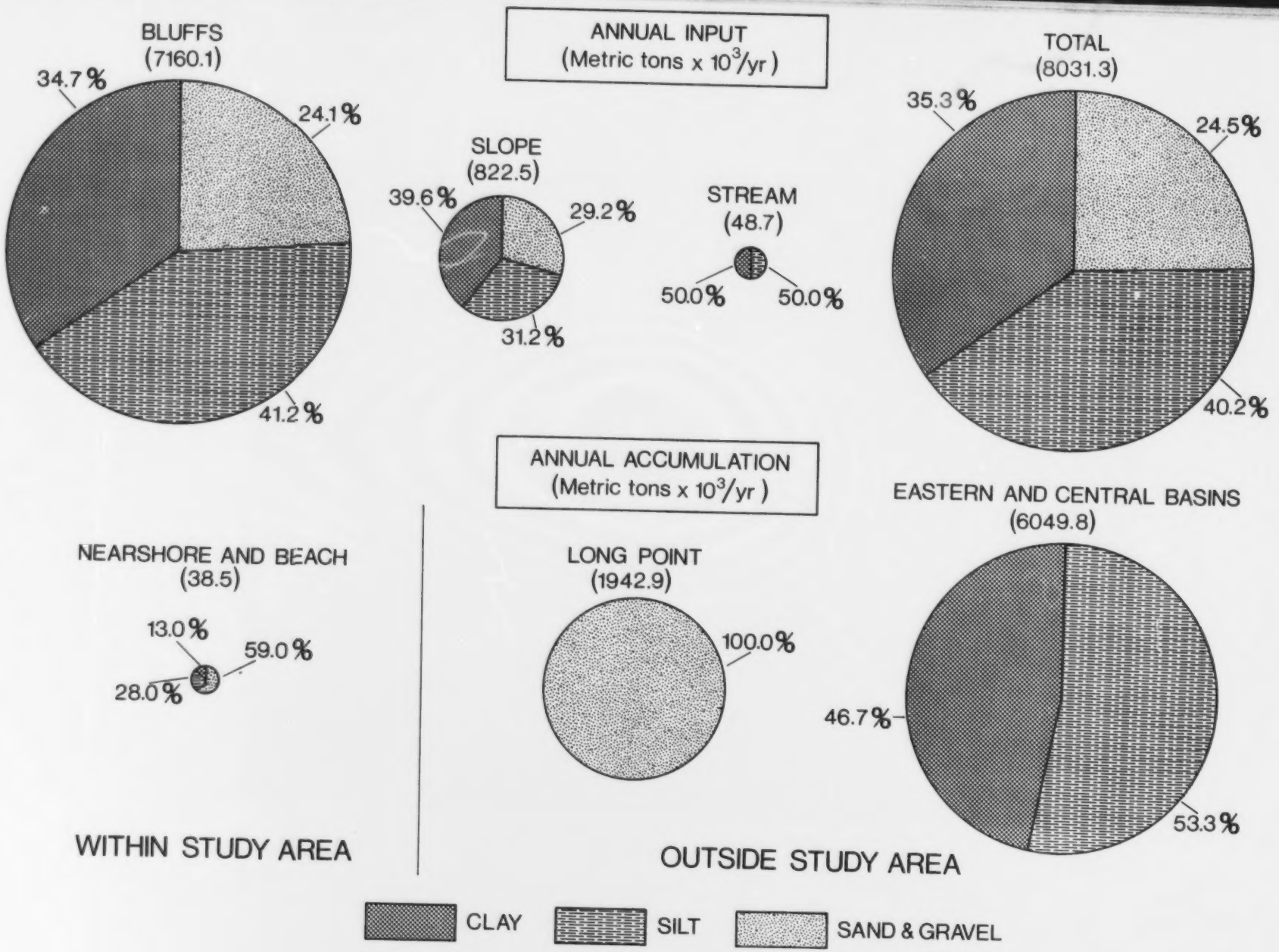


Figure 11 Coastal sediment budget, North-Central shore of Lake Erie.

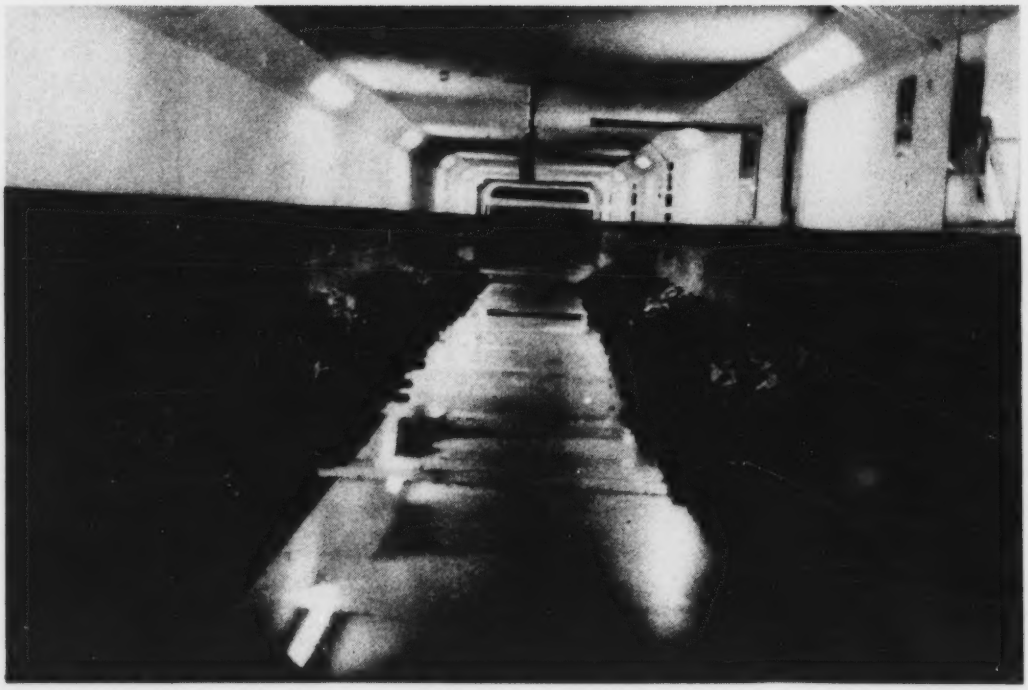


Figure 12 View of riprap-lined flume walls for wave attenuation tests.

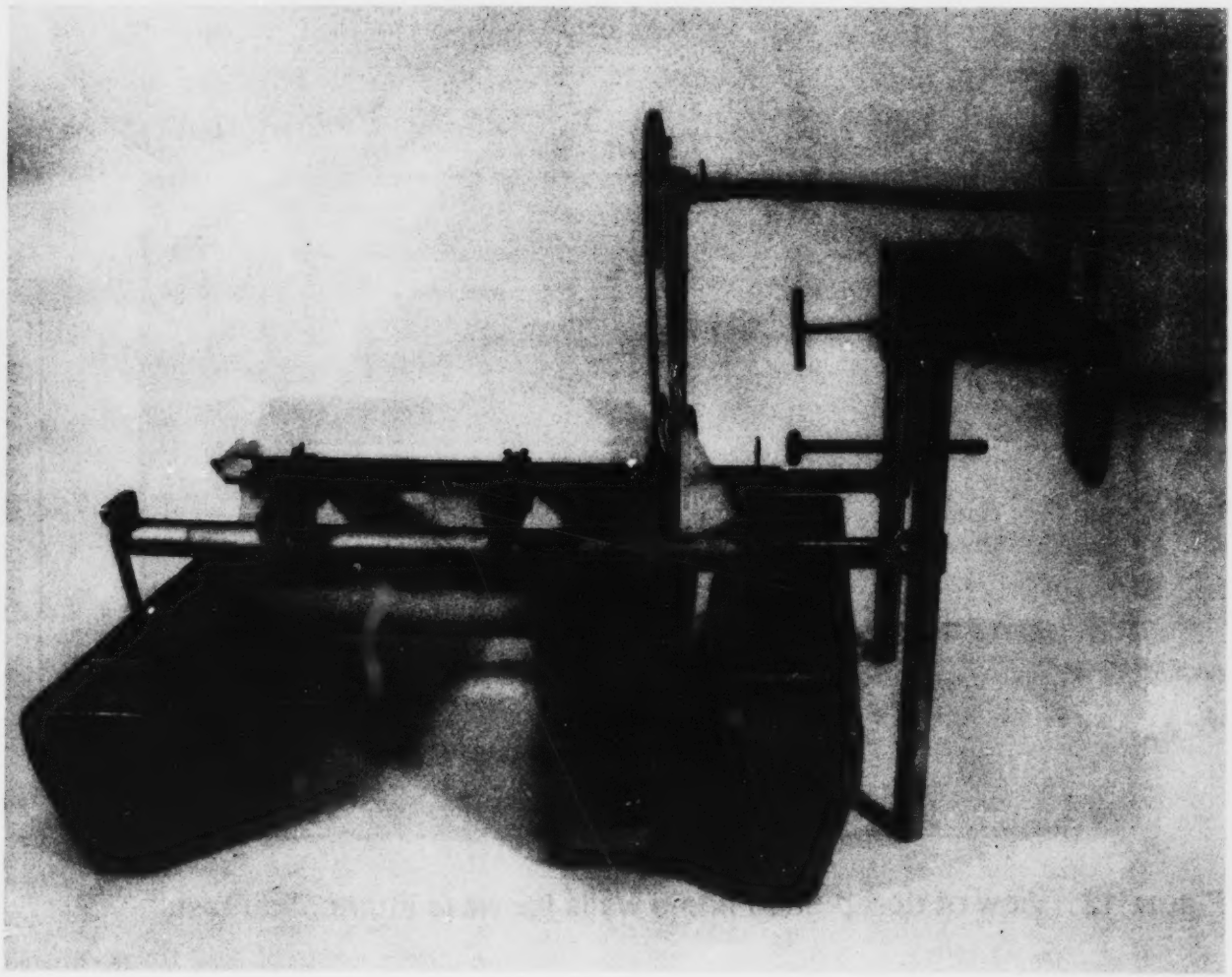
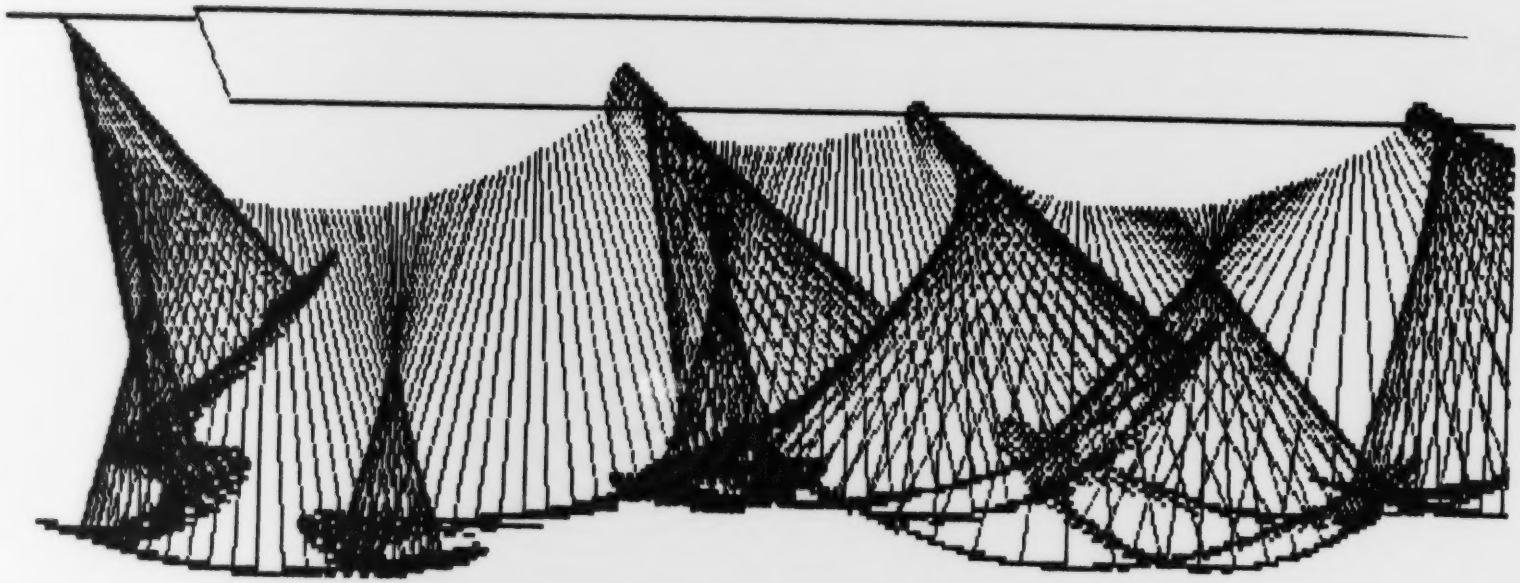


Figure 13 Mini surface sampler.



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1000 REM M1=2.5 M2=1.60 Z=2 R1=.1 R2=.3 R3=0.05 V=.5 V10=.5 G0=.75 R-D .088kg
```

Figure 14 Profiler model track.

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